(2)

Report VSE/ASD/0121-88/26RD

AD-A210 720

FINAL TECHNICAL REPORT FOR TEST SUPPORT OF THE 18K BTUH COMPACT TOTAL ENVIRONMENTAL CONTROL SYSTEM (TECS), 0500.0121

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

16 September 1988

Final Report for Period 14 March 1988 through 16 September 1988

Approved for public release; distribution is unlimited.

Prepared for:

U.S. Army Belvoir Research, Development and Engineering Center
Environmental Control Division (STRBE-FED)
Fort Belvoir, VA 22060-5606

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

12

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) VSE/ASD/0121-88/26RD	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION VSE Corporation 6b. OFFICE SYMBOL (If applicable) ASD	7a. NAME OF MONITORING ORGANIZATION Environmental Control Division (STRBE-FED)
6c. ADDRESS (City, State, and ZIP Code) 2550 Huntington Avenue Alexandria, VA 22303-1499	7b. ADDRESS (City, State, and ZIP Code) U.S. Army Belvoir Research, Development and Engineering Center (Belvoir) Fort Belvoir, VA 22060-5606
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable) STRBE-FED	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAK70-86-D-0023
8c. ADDRESS (City, State, and ZIP Code) U.S. Army Belvoir Research, Development and Engineering Center Fort Belvoir, VA 22060-5606	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. 0500 / TASK NO. 0121 / WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) Final Technical Report for Test Support of the 18K BTUH Compact Total Environmental Control System (TECS)	
12. PERSONAL AUTHOR(S) Baker, Mark S.	
13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 88/3/14 TO 88/9/16	14. DATE OF REPORT (Year, Month, Day) 88/9/16 15. PAGE COUNT 9
16. SUPPLEMENTARY NOTATION Destroy this report when no longer needed. Do not return to the originator.	

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
18K BTUH Vertical TECS, 18 K BTUH Horizontal TECS, Test Support, Motor Controller, Logic Assembly, Commercial Compressors Southcon, Keco, Baseline Testing, (Con't in Block 19)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

VSE provided technical support to Belvoir's testing program for the 18K BTUH Vertical and Horizontal TECS air conditioners during the period of 14 March 1988 to 16 September 1988. VSE technical support consisted of participation in monthly Government reviews of ongoing testing, troubleshooting support following equipment failures and shop labor services for substituting military for commercial compressors in four (4) air conditioners. The Southcon and Keco motor controllers have each experienced failures. Following each major failure the motor controllers were shipped back to the manufacturer for failure analysis. As of the date of this report, testing is behind schedule due to motor controller failures.

Block 18 Con't - Design Verification Testing, Failure Analysis,

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Mr. Thomas Sgroi	22b. TELEPHONE (Include Area Code) (703) 664-6031 22c. OFFICE SYMBOL STRBE-FED

SUMMARY

Task Order 0121 required that the contractor provide general technical services to the Environmental Control Division of the Belvoir Research, Development and Engineering Center, Fort Belvoir, Virginia in support of the Government's 18,000 BTUH Total Environmental Control System (TECS) testing program. Testing must be completed on both Vertical and Horizontal air conditioners by 31 Dec 1988 in order to comply with TROSCOM's schedule for Belvoir to provide a complete 18K TECS Technical Data Package (TDP) by Feb 1989. Fort Belvoir intends to complete all testing by 23 Nov 1988.

Support services provided included interchanging of commercial compressors for military design compressors, participation in testing review meetings, air conditioner malfunction troubleshooting, interacting with motor controller manufacturer's, shipping and photographic services.

The motor controller manufacturers, Southcon and Keco Industries, have both experienced failures or improper operation during testing. Southcon has diagnosed, reworked and returned their motor controllers which had not operated properly. The Keco motor controller catastrophic failures occurred relatively recently in the test program. No failure analysis or reworked motor controllers have been received from Keco to date.

Testing continues at Fort Belvoir. The test schedule may slip due to motor controller failures.

PREFACE

This Final Technical Report was prepared under Contract No. DAAK70-86-D-0023, Task Order 0121, for the Belvoir Research, Development and Engineering Center (Belvoir), Fort Belvoir, Virginia. Mr. Thomas Sgroi served as the Belvoir Contracting Officer's Representative, telephone no. (703) 664-6031.

This report represents the final effort for test support of the 18K BTUH TECS air conditioners to be provided under Task Order 0121. The required effort in the Task Order statement of work is quoted below:

> "The contractor shall provide engineering evaluation, design/redesign, prototype manufacturing, documentation and testing services in support of the Army's 18K BTUH "Soft Start" Horizontal and Vertical Air Conditioner Program using knowledge gained during the performance of Contract No. DAAK70-86-D-0023, Task Order Numbers 0001, 0039 and 0074."

TABLE OF CONTENTS

1.0 INTRODUCTION

Task Order 0121 required VSE Corporation to provide technical support during Government testing of the 18,000 BTUH Total Environmental Control System (TECS) Vertical and Horizontal air conditioners (which were modified under Contract No. DAAK70-86-D-0023, Task Order No. 0074) during the period of 14 March 1988 to 16 September 1988. The testing program was required to evaluate performance and impact of soft start motor controllers and motor controller logic circuitry installed internally into six (6) prototype Vertical TECS units and six (6) prototype Horizontal TECS units. Electronic motor controllers using pulse-width modulation inverters from two manufacturers (Keco Industries (Keco) and Southern Industrial Controls, (Southcon)) were tested in the prototype air conditioners.

All testing was to be accomplished at Fort Belvoir test facilities. The Master Test Plan included the following:

- Baseline testing of two unmodified Vertical Military Compact air conditioners and two unmodified Horizontal Military Compact air conditioners. These four units are referred to as baseline units.

- Testing of four baseline units following Belvoir installation of Copeland commercial compressors.

- Testing of four baseline units following VSE installation of motor controllers, controller logic and reinstallation of original military compressors for the remaining design verification testing. Design verification testing included use of eight (8) additional air conditioners, four Vertical and four Horizontal units, for reliability testing. (These are referred to as reliability units).

The primary purpose for VSE support during Government testing was to assist in resolving problems encountered with the motor controllers, their associated logic circuitry and the modified air conditioners.

2.0 DISCUSSION

2.1 General. VSE technical support for the Government 18,000 BTUH TECS test program primarily consisted of VSE participation in monthly Government reviews of ongoing testing, shop labor services to substitute military for commercial compressors, and on call troubleshooting support following equipment problems or failures.

Many problems existed with the Southcon motor controllers prior to initiation of Belvoir's formal test program. Southcon had to rework the units following their initial submittal to VSE since the motor controllers did not operate in the TECS air conditioners. The initial problem stemmed from an inadequate 12 vdc power supply transformer in their motor controllers. Various problems have continued with the Southcon motor controllers during Belvoir testing. The Keco motor controllers have also experienced failures during testing, however Keco has generally met with more success then Southcon. This is to be expected since Keco, a manufacturer of military standard air conditioners, is

intimately familiar with the air conditioners and the environmental conditions under which they must operate. Also, Keco has provided motor controllers for other military applications and developed a prototype motor controller for use in military air conditioners prior to their subcontract under VSE for the motor controller currently under test.

2.2 Commercial Compressor (Copeland Corporation). During the course of the testing program Belvoir substituted Copeland Corporation Model CRD1-0200-TF5 compressors, with a nominal rating of 24,000 BTUH, for the original military design compressors in the baseline air conditioners. The air conditioners did not pass the cooling capacity test with the commercial compressors installed. Belvoir then directed VSE to replace the commercial compressors with the original military compressors to complete the remaining testing.

2.3 Southcon Motor Controller. Several Southcon motor controllers experienced shutdowns during high temperature testing. The motor controller shutdown and provided an "OVERCURRENT" fault signal. Subsequent discussions with Southcon personnel revealed that the motor controller output current is monitored and limited to no more than 18 amps (air conditioner current draw during normal conditions) as opposed to limiting the input current which was specified in the motor controller purchase description. Limiting the output current to 18 amps does not allow proper operation of the compressor during simultaneous low voltage and high temperature conditions when the air conditioner motors must draw approximately 21 amps due to the increased cooling load.

An air conditioner with a Southcon motor controller installed passed the conducted emissions (CE03) portion of the electromagnetic interference (EMI) test. However, the same air conditioner failed the radiated emissions (RE02) portion of the EMI test. The Southcon controller is provided with EMI gasketing along the enclosure box perimeter. The motor controller input and output power lines are shielded. Power lines internal to the air conditioner which interface with the motor controller conductors, however, are not shielded. These unshielded power lines may have caused the radiated emissions test failure.

Other deficiencies discovered with the Southcon controllers include no fault signal being transmitted to logic assembly when the motor controller overheats. The motor controller will shut itself down on overtemperature, but no 12 VDC fault signal is provided to the logic assembly as specified in the purchase description. Belvoir tests also indicate that the motor controller may not provide a fault signal on low voltage as required by the purchase description.

2.4 Keco Motor Controller. A Keco motor controller failed during an air conditioner performance test conducted where the outdoor side was exposed to 120°F and the indoor side was exposed to 90°F. The unit was shipped back to Keco for failure analysis. Preliminary analysis from Keco indicated that all three power transistor modules burned out. Additional transistors were also damaged. As of the date of this report, Keco has not yet hypothesized the cause of failure.

An air conditioner with a Keco motor controller installed passed the conducted emissions (CE03) portion of the EMI test. However, the same air conditioner failed the radiated emissions (RE02) portion of the EMI test. The Keco controller is not provided with EMI gasketing along the access panel perimeter. The motor controller input and output power lines are shielded. However, power lines internal to the air conditioner which interface with the motor controller conductors are not shielded. These unshielded power lines may have caused the radiated emissions test failure.

During the last week of this Task Order another Keco motor controller failed during reliability testing following approximately 200 hours of operation. The failed motor controller has been shipped to Keco for failure analysis.

2.5 VSE Logic Assembly. On one of the test air conditioners, a fault signal was given when the unit was energized. Upon visual inspection of the printed circuit board in the logic assembly by Belvoir, two solder bridges were discovered. The solder bridges were eliminated and the logic assembly performed satisfactorily.

As of the date of this report, all baseline testing has been completed with the air conditioners in the unmodified condition and all baseline testing has been completed with the commercial compressors installed in the air conditioners. Performance testing has been completed on four (4) of eight (8) reliability units (with military compressors). Two reliability units are currently undergoing the reliability test.

3.0 CONCLUSION

Southcon did not comply with the requirements of the VSE purchase description by providing motor controllers which limit output current to 18 amps instead of input current. Current is sensed on the output side due to the single phase and three phase power inputs to the air conditioners. The motor controller output current ability must be at least 21.5 amps to allow operation during the low voltage/high temperature test. It is believed that the input current (for three phase input power) will still remain below 18 amps under these conditions. All Southcon motor controllers have been subsequently reworked by Southcon to correct this deficiency.

Southcon motor controllers do not provide 12 VDC fault signals for motor controller overtemperature and possibly not for low voltage. Southcon did not comply with the requirements of the VSE purchase description regarding fault signals. Southcon's motor controllers have had no catastrophic failures, although little test time has been logged thus far.

Keco motor controllers have experienced two separate major failures during testing. The motor controllers have been shipped back to the manufacturer for failure analysis. To date, no feedback regarding failure mode has been provided to VSE.

Air conditioners with both Southcon and Keco motor controllers installed passed the conducted emissions portion of the EMI test. Those results indicate that the radio frequency interference (RFI) filter, provided by VSE,

is adequate for the application. Neither the Southcon nor the Keco motor controllers passed the radiated emissions portion of the EMI test. It is believed that unshielded power lines inside the air conditioner are acting as antenna and radiating excessive electromagnetic waves.

The Copeland commercial compressors failed to produce adequate capacity in the air conditioner during cooling capacity testing. All commercial compressors were replaced with the original military compressors for remaining design verification testing.

4.0 RECOMMENDATION

Future Southcon motor controllers must provide fault signals for motor controller overtemperature and low voltage. To retrofit the existing motor controllers to provide the fault signals would require major rework and expense. This retrofit need not be performed on the eight (8) prototype Southcon motor controllers.

The two failed Keco motor controllers must be evaluated as to mode of failure; modified, if design or hardware deficiencies are indicated; repaired and returned for further testing.

Air conditioners with both Southcon and Keco motor controllers installed did not pass the radiated portion of the EMI test. It is recommended that EMI protective tape be applied to unprotected power lines internal to the test air conditioners. The air conditioners should then be retested for radiated EMI.